

1/22/03 Investigations at GSFC on the effect that various TDC settings (accessible from the GSE), and Rates, had on the behavior of the IMS TDC

The TDC Control page on the IMS GSE has the following controls:-

<u>Controls</u>	<u>Default Setting</u>
TDC Reset	Off
Paralyzable dead time	Off
FIFO Full Disable	Off
Singles – ID/TOF Coinc. Req'd	On
TDC – ID/TOF Coinc. Req'd	On
Enable Threshold Adjust	On
Enable BIT	Off
2 Hit / 1 Hit	2 Hit
Max TOF (0-15)	15
Deadtime (2, 4, 8, 16)	2us
Vernier Adjust (0, 1, 2, 3)	0

The first set of experiments was performed with a “Medium Intensity Beam.

Plot 1. Here we plot Starts as a function of Dead Time Setting (2,4,8,or 16us)

This is done for all 8 combinations of

“Paralyzable dead time”,

“Singles – ID/TOF Coinc. Req'd”,

“Double Hit”

Appears that rates go down a little with increasing dead time, but the most significant effect is to turn the “Singles – ID/TOF Coinc. Req'd” off. Rates jump from ~ 12000 to 16000 Hz.

Plot 2. Here we plot St Stops as a function of Dead Time Setting (2,4,8,or 16us)

Appears that rates go down a little with increasing dead time, but not much. The one condition that stands out is to Paralyzable On, Single Hit, Coinc. Req'd ...Count rate ~ 10% lower !.

Now using “High Intensity Beam.

Plot 3. Here we plot Starts as a function of Dead Time Setting (2,4,8,or 16us)

Appears that rates go down a little with increasing dead time, but the most significant effect is to turn the “Singles – ID/TOF Coinc. Req'd” off. Rates jump from ~ 12000 to 20000 Hz.

Plot 4, Here we plot St Stops as a function of Dead Time Setting (2,4,8,or 16us)

Rates go down a little with increasing dead time. The major (though not only) predictor that affects the measured rate is “Single Hit, Coinc. Req'd” if on then count rate ~ 20% lower !.

Plot 5. Here “Paralyzable Dead Time” is Off.

Plot Starts, St Stops for conditions:- “ID/TOF Coinc. Req’d” both On and Off.

This was done as we decreased the beam intensity (by simply reducing filament current in Ion Gun, - all other parameters remained constant). The absolute beam intensity is not known, counts were recorded as it was monotonically reduced. The actual order of data taking was from Run 9 to 1.

The Starts and Stops track reasonably well at low beam intensities through Run 5, the Start rate is actually higher than the St Stop rate. For Runs > 6, the Starts appear are suppressed relative to the St Stops (Same MCP Plate !) This has been noted previously, during Plateau Curve investigations.

Note at the higher rates, the “ID/TOF Coinc. Req’d” Off has a more significant effect on the Starts (~75% increase), as compared to the St. Stops (only a 19% increase).

All data obtained to date with the IMS at GSFC e.g. Plateau curve studies, were done with the “ID/TOF Coinc. Req’d” On.

Plot 5b. As above, but data replotted, normalizing to the St Stops, “ID/TOF Coinc. Req’d” Off case. The St Stops data “ID/TOF Coinc. Req’d” Off normalized to Max value is also shown.

Plots 6, 6b. As Plot 5, and 5b but “Paralyzable Dead Time” is now On. No noticeable changes to above.

Plot 7. Here we plot Starts for each anode, LEF Stops, ST Stops, Time Outs, Single TOF, Double TOF as indicated by the IMS GSE.

A 10keV, relatively Low intensity N₂⁺ beam was directed at Anode 4 of the IMS. Counts were recorded for each of the following conditions, All Anodes Enabled, “Front End Electronics” configured so Only Anode 4 enabled, Default Settings, Singles – ID/TOF Coincidence Req’d (Off), TDC-ID/TOF Coincidence Req’d (Off), Both requirements (Off).

Although the beam was directed at Anode 4, a small but significant count rates were recorded in the other Anodes, as has previously been the case. This “cross-talk” has always been there. The exception is Anode 5, which has not given any counts since a MCP HV discharge took place some time ago.

Anode 4, LEF Stop, and the ST Stop channels, all have a higher rate small (1-3%) , when only Anode 4 is enabled.

We conclude that this cannot be a MCP saturation effect, as beam intensity is not changed.

Is it possible that thresholds change in the FEE as a function of total countrates ?

More significant is the effect of removing the Singles ID/TOF Coincidence Requirement, - the Anode 4 Start rate increases by ~18-20%. Likewise the LEF stop rate increases (~30%), but the effect is reduced to ~7% for the ST Stop rate.

Again this cannot be a MCP saturation effect, as beam intensity is not changed.

Re. Time Outs, these appear to depend only on whether or not “Anode 4 only” is enabled.

Re. Single TOF, these rates depend on whether the “Singles – ID/TOF Coinc. Req.” is enabled.

Likewise the Double TOF.

Plot 8. As plot 7 above, but now we are using a much more intense beam. At least a factor of 10 higher, (possibly 16 if we compare ST Stop rates).

As has been seen before, the ST start rate in Anode 4, appears to max out at ~10,000. (increases significantly to ~ 20,000 when we remove the “Singles – ID/TOF Coincidence requirement.”)

The LEF Stops have increased to 37,000 (50,000 without coinc. Requirement)

The ST Stops increased to ~70,000 (140,000 without coinc. Requirement)

It appears that the Starts are definitely suppressed as compared to the St Stop rate. From the above facts, we deduce that at least a factor of 2 of this is due to FEE/TDC. The rest may be due to MCP saturation effects, though we cannot be certain at this stage.

Notes on the Built In Test mode for the TDC.

It was possible to choose a ST and LEF Threshold, such that we had 6250 counts in Starts and whichever Stop was enabled. Note: Time period = 100ms. The dead times were 50% of this (3125), as was the Single TOF and SAM Strobe rates. The Start CFD rate was 50% higher or 9375. The Stop CFD rate was 6250. I do not have any explanation for this, but it does not seem to do what I expected it to do. Also the ST delay has to be “0” otherwise there are no ST coincidences. The LEF delay works as expected. The TDC has to be in the 1 Hit mode for these tests to work.

			Changes Noted			
TDC	Paralyzable Dendtime	Off			ON	Off
	FIFO Full Disable	Off				
	Singles - ID/TOF Coin. Req'd	ON				
	TDC - ID/TOF Coin. Req'd	ON				
	Enable Threshold Adjust	ON				
	Enable Bit	ON				
	2Hit / 1 Hit	1				
	Max TOF (0-15)	15				
	Deadtime (2,4,8,16)	2				4
	Vernier Adjust	0				
FEE	Anode 4	ON				
	Hi Res	ON		Of		
	Med Res	Off		ON		
	Start BIT	ON				
	ST BIT	Off		ON		
	LEF BIT	ON		Off		
	ST Thr	4				
	LEF Thr	4	5-13	7-15		
BIT	LEF Delay	4		4		
	ST Delay	2		0		
	Frequency	0		0		
	Anode 4	6250	6250	6250		
	LEF	3147	6232	0		
	ST	0	0	6248		
	Time Out	0	0	25	3125	3124
	Errors	6	5	1	3125	
	Dead Time	3125	3125	3125	3125	
	Single TOF	3116	3121	3123	3122	
	Double TOF	0	0	0	0	
	SAM Strobe	3114	3122	3120	3125	
	Resets	0	0	0	0	
	START CFD	9375	9375	9375	9375	
	STOP CFD	6244	6238	6250	6252	

Finally a number of experiments were performed using external stimuli for the “Built In Test” mode. This was accomplished by placing a breakout box between the TDC (outside the Vac Chamber) and the FEE. Pulses (random and variable frequency) could be applied to the Start or Stop inputs to the FEE. It was noted that applying a frequency $=f$ to either the BIT Start or Stop, resulted in a corresponding response $=f/2$. eg apply 50,000 Hz to BIT anode 4 starts, we get 25,000 displayed on the GSE. This may have something to do with thresholds, or the fact that the breakout box introduced reflections etc in the signal lines. Under certain conditions, the Stop CFD would give the “correct rate” f , while the “singles” would only give $f/2$. This is possibly due to slightly different thresholds for the CFD’s and the Singles ID. Even in the case of just using the BIT, similar differences may be observed. Possibly the CFD’s are triggering on rising and falling edges of the pulses, whereas the ID Singles may not be as sensitive, and hence give the expected rates.

The following data was taken under the conditions of observed singles rates = applied rates/2
(**Note:** only LEF data can be obtained using BIT or External pulses +BIT due to crosstalk on the “Starts” and “Straight through” anodes.)

Plot 9 Here a fixed frequency (25kHz) was applied to (Anode 4) Starts.

LEF stops were random in the range 0-450kHz. – (X-Axis)

Plotted are the IMS responses:-

- 1) LEF Stops under default TDC config.
- 2) LEF Stops, with condition “Singles ID-TOF Coin not Req’d”
- 3) Singles TOF (RHS axis)
- 4) Singles TOF, with condition “Singles ID-TOF Coin not Req’d” (RHS axis)

Note: the first 2 plots track the random rate well to $\sim 100,000$ then they start to fall off with increasing applied LEF Stop rate. e.g. at rate of 300,000Hz, the LEF Stops drop to 225,000 and 250,000 for the condition with and without ID-TOF coin req’d.

TDC range $\sim 2048 \times 0.75\text{ns/channel} = 1536\text{ns}$

From the data, we see at a rate of e.g. 100,000 the singles coincidence rate is 7500.

If we say that accidental coin rate $= n_1 \times n_2 \times (\text{TDC range})$

$25000 \times 100000 \times 1536 / 10^9 = 3840$

This is almost exactly a factor of 2 too low. (See 1st paragraph for req’d factors of 2)

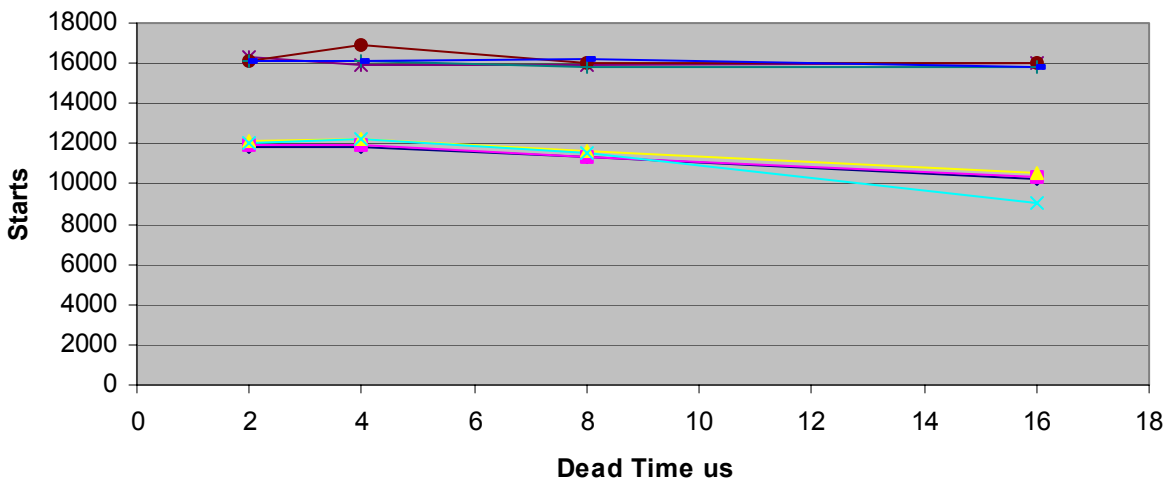
Plot 10 Here conditions as above, only signals at the breakout box were switched, now LEF Stops fixed (25,000) and Starts Anode 4 are random.

Looking at the TOF rates, - at 100,000 random Starts and 25,000 now get fewer coincidences, (~ 6000) than before (7500). Also the rate at which the Singles falls off (Singles ID-Coin Req’d) is greater than before for large Random Start pulse rates ($> 100\text{kHz}$).

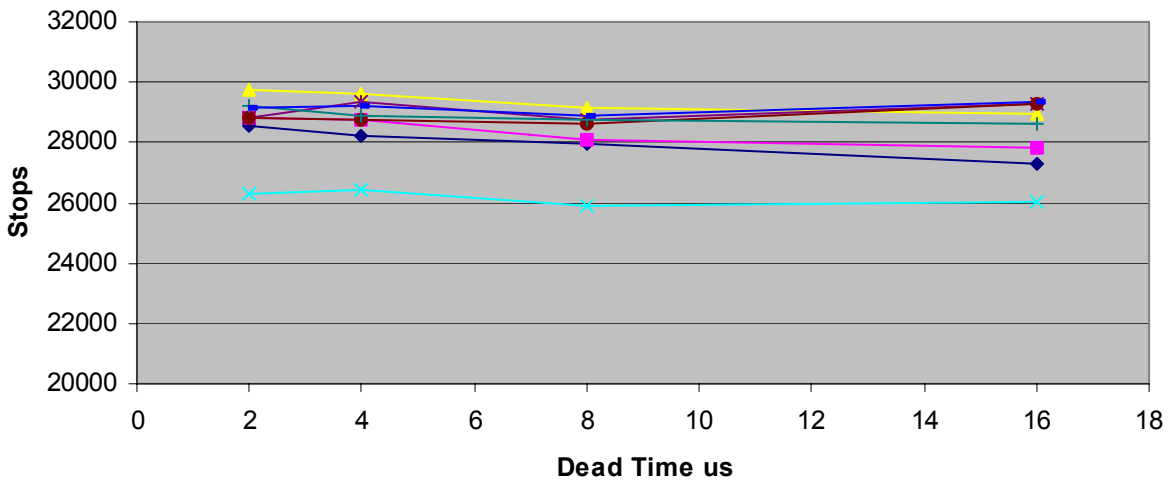
Conclusion

I believe the TDC works as expected to rates $\sim \geq 450\text{kHz}$. Fall off in efficiencies are in keeping with what one may expect due to e.g. deadtime effects, though this may require further verification. Certain effects e.g. factors of 2 in applied versus observed rates may be due to our setup, but essential thing here is that the TDC behaves as expected at high rates, and anything happening at low rates, is most likely due to local saturation effects in the MCP plates, not the TDC.

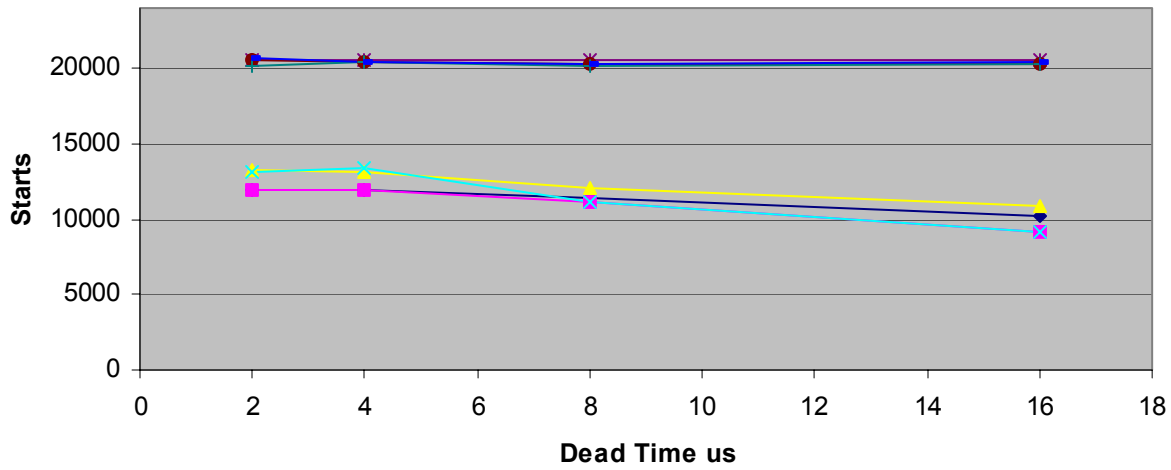
12/16/02 Plot 1, Starts, Medium Intensity Beam



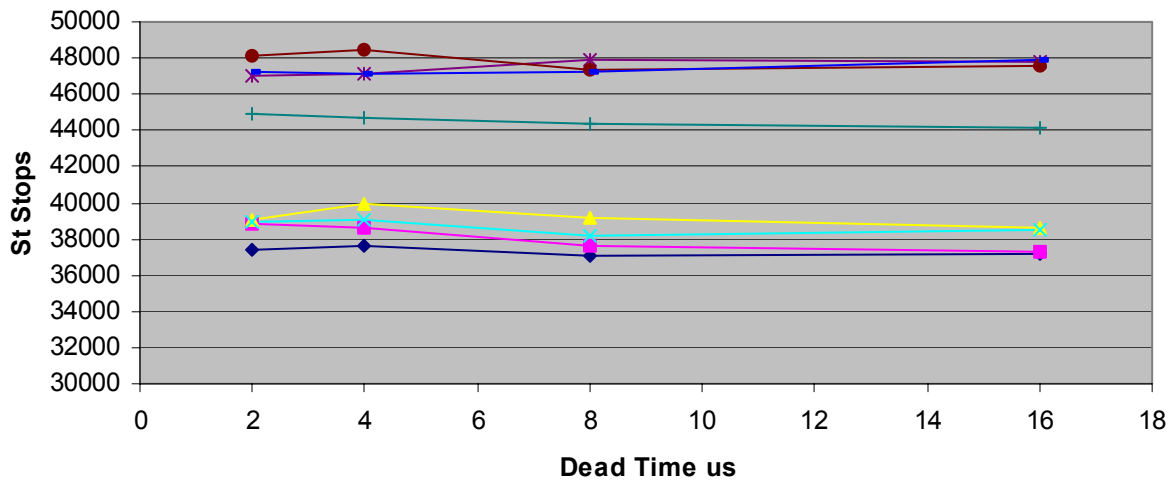
12/16/02 Plot 2, ST Stops, Medium Intensity Beam



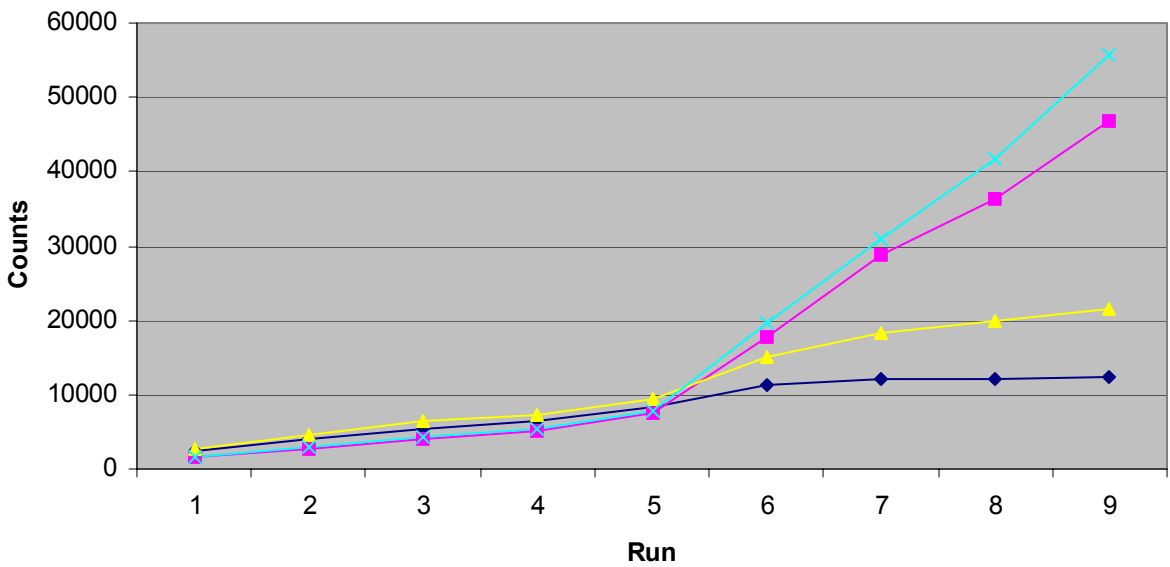
12/16/02 Plot 3, Starts, High Intensity Beam



12/16/02 Plot 4, St Stops, High Intensity Beam

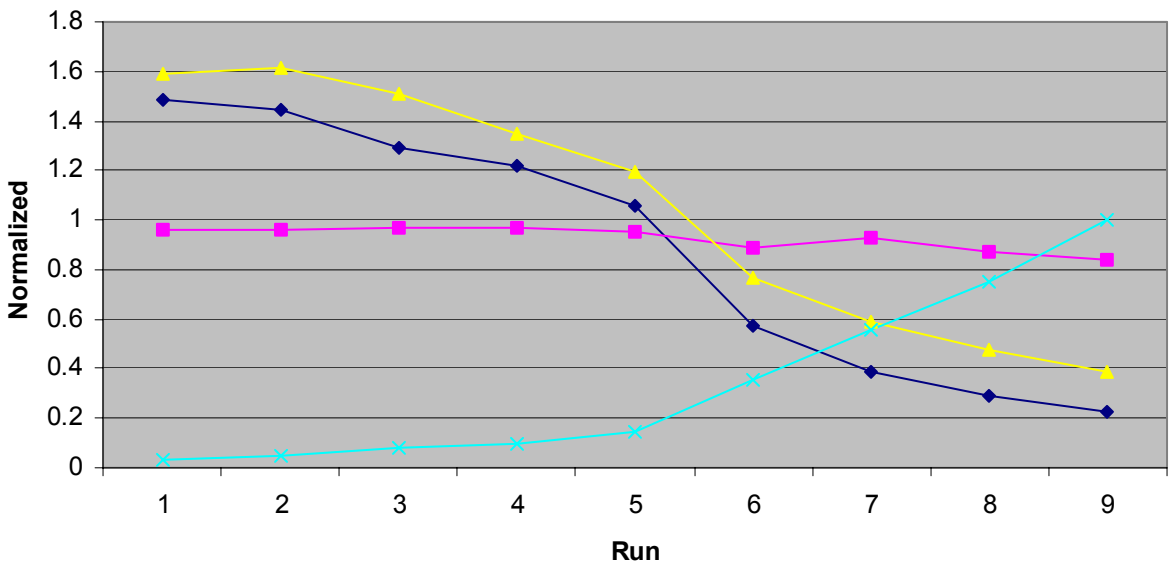


12/16/02 Plot 5, St Stop, Starts as Fn Beam Inten., Para. DT Off



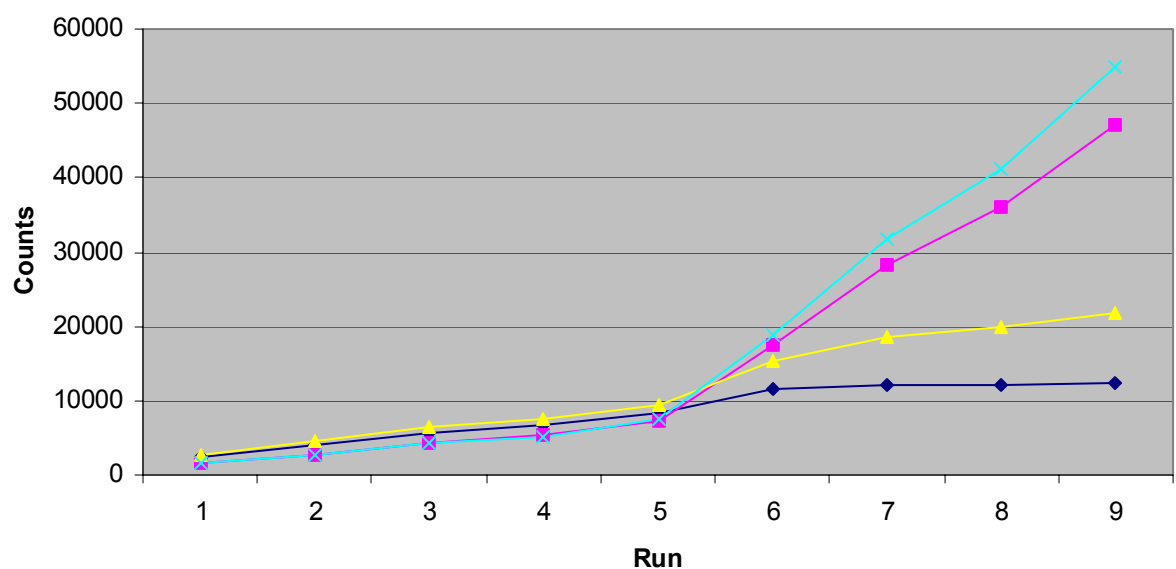
◆ Starts, Singles – ID/TOF Coinc. Req'd On, ■ St Stops, Singles – ID/TOF Coinc. Req'd On,
 ▲ Starts, Singles – ID/TOF Coinc. Req'd Off, ✕ St Stops, Singles – ID/TOF Coinc. Req'd Off,

12/16/02 Plot 5b, Normalized to "St Stops, ID/TOF Off"



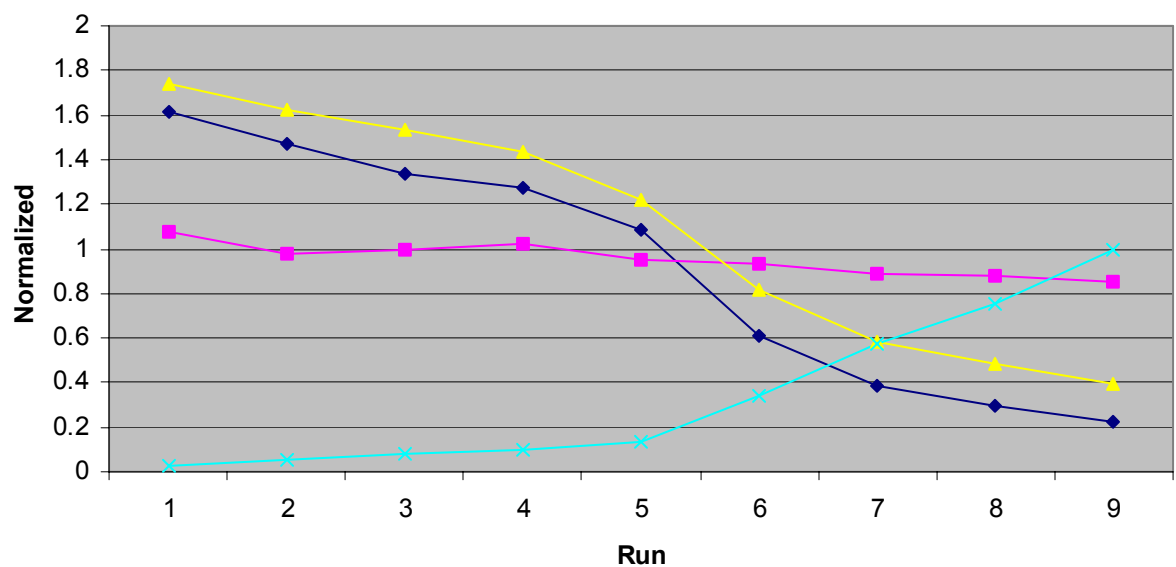
◆ Starts, Singles – ID/TOF Coinc. Req'd On, ■ St Stops, Singles – ID/TOF Coinc. Req'd On,
 ▲ Starts, Singles – ID/TOF Coinc. Req'd Off, ✕ St Stops, – ID/TOF Req'd Off, Norm to Max

12/16/02 Plot 6, St Stops, Starts as Fn Beam Inten., Para. DT On



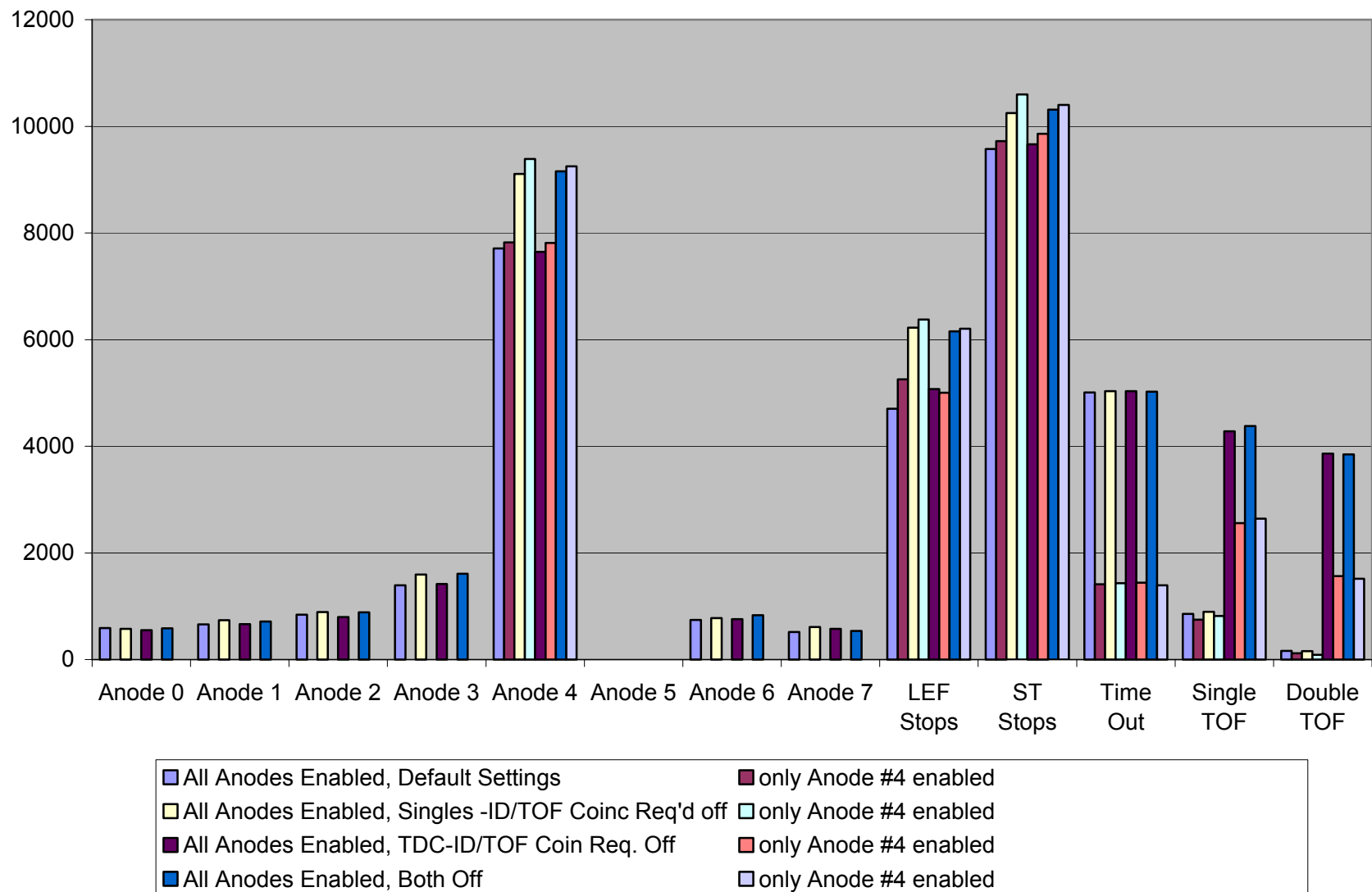
◆ Starts, Singles – ID/TOF Coinc. Req'd On, ■ St Stops, Singles – ID/TOF Coinc. Req'd On,
 ▲ Starts, Singles – ID/TOF Coinc. Req'd Off, × St Stops, Singles – ID/TOF Coinc. Req'd Off,

12/16/02 Plot 6b, Normalized to "St Stops, ID/TOF On"

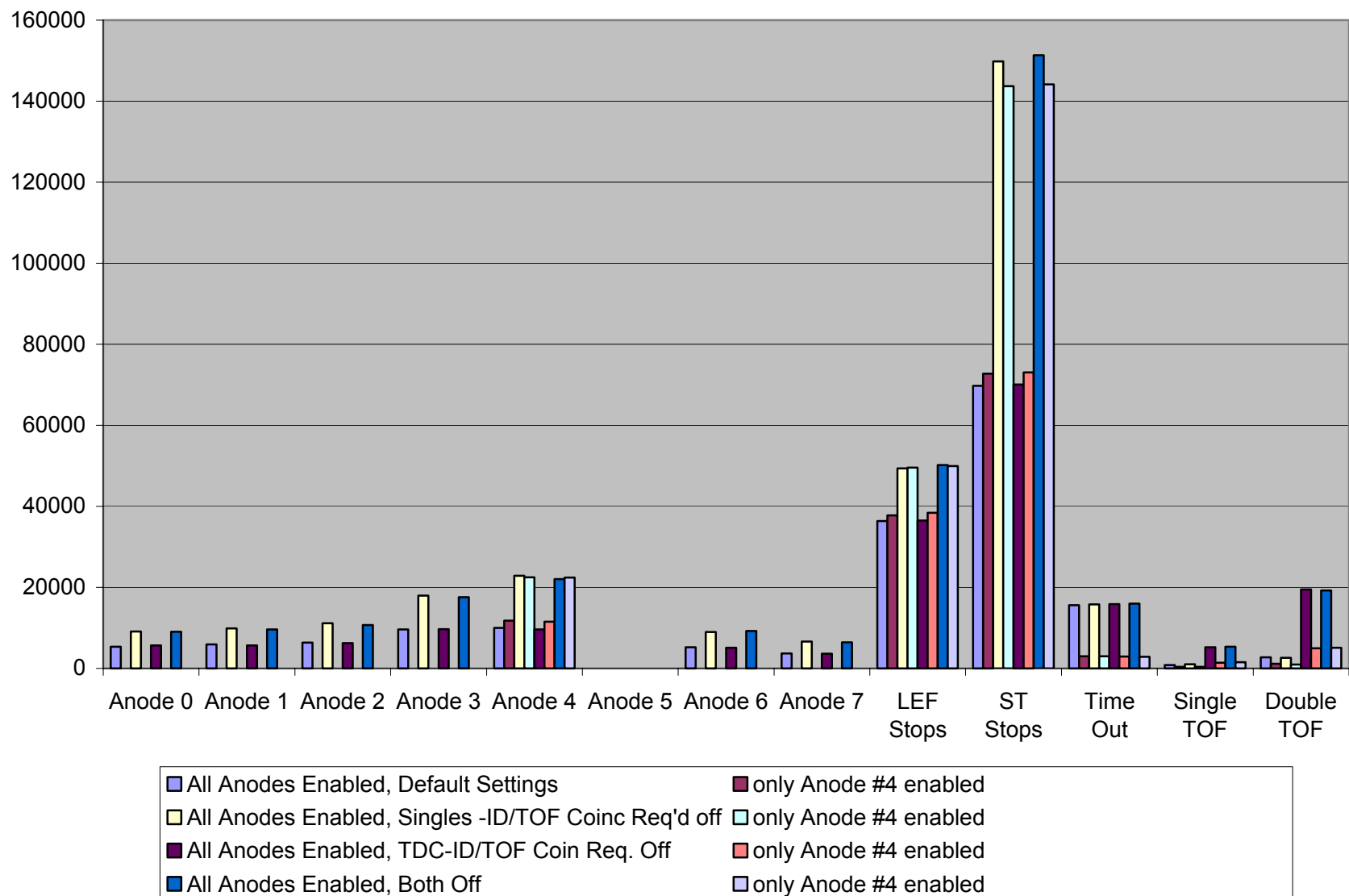


◆ Starts, Singles – ID/TOF Coinc. Req'd On, ■ St Stops, Singles – ID/TOF Coinc. Req'd On,
 ▲ Starts, Singles – ID/TOF Coinc. Req'd Off, × St Stops, – ID/TOF Req'd Off, Norm to Max

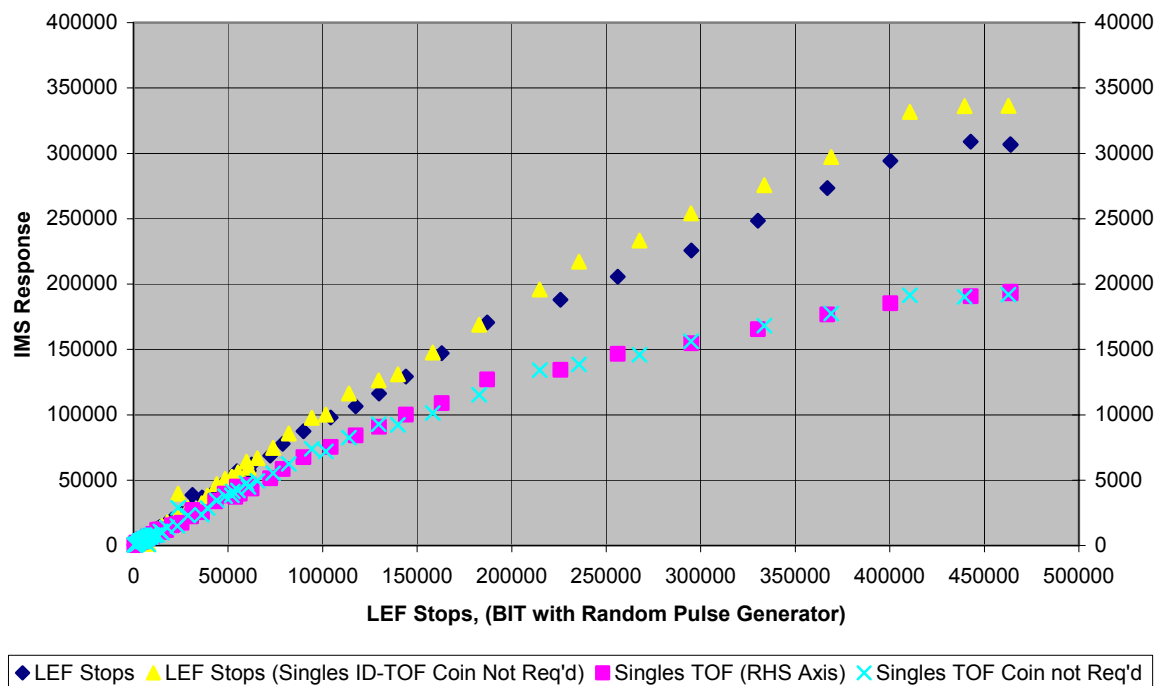
1/14/03 Plot7, 10keV N2+ Low Intensity



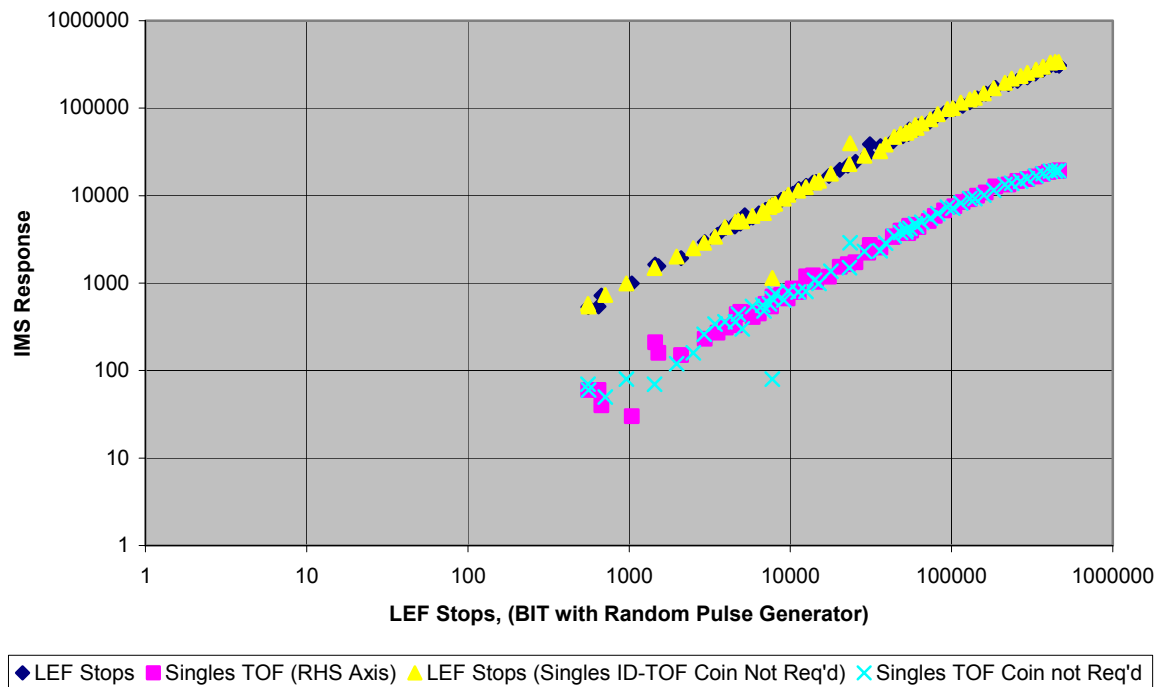
1/14/03 Plot 8, 10keV N2+ High Intensity



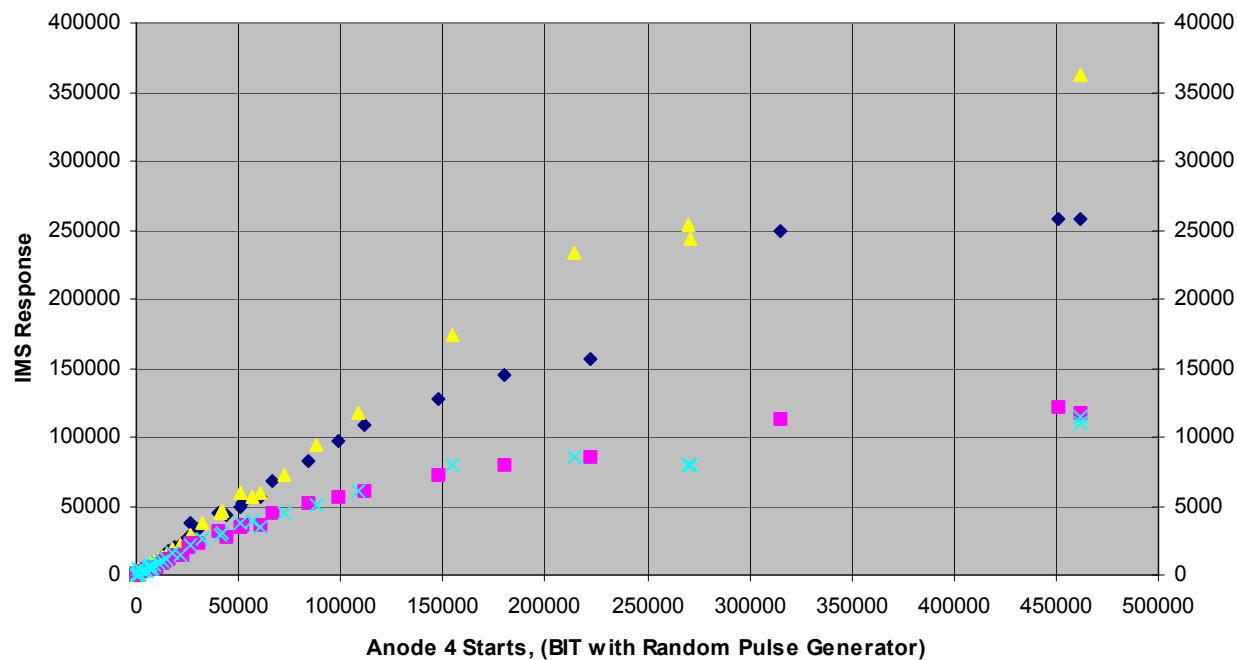
2/4/2003, Plot 9, IMS158,159 Anode 4 (Starts) fixed at 25000Hz, Random Stops,



2/4/2003, Plot 9 (Log), IMS158,159 Anode 4 (Starts) fixed at 25000Hz, Random Stops,



2/4/2003, Plot 10, IMS 160,161 LEF Stops fixed at 25000Hz, Random Starts Anode 4



2/4/2003, Plot 10, IMS 160,161 LEF Stops fixed at 25000Hz, Random Starts Anode 4

